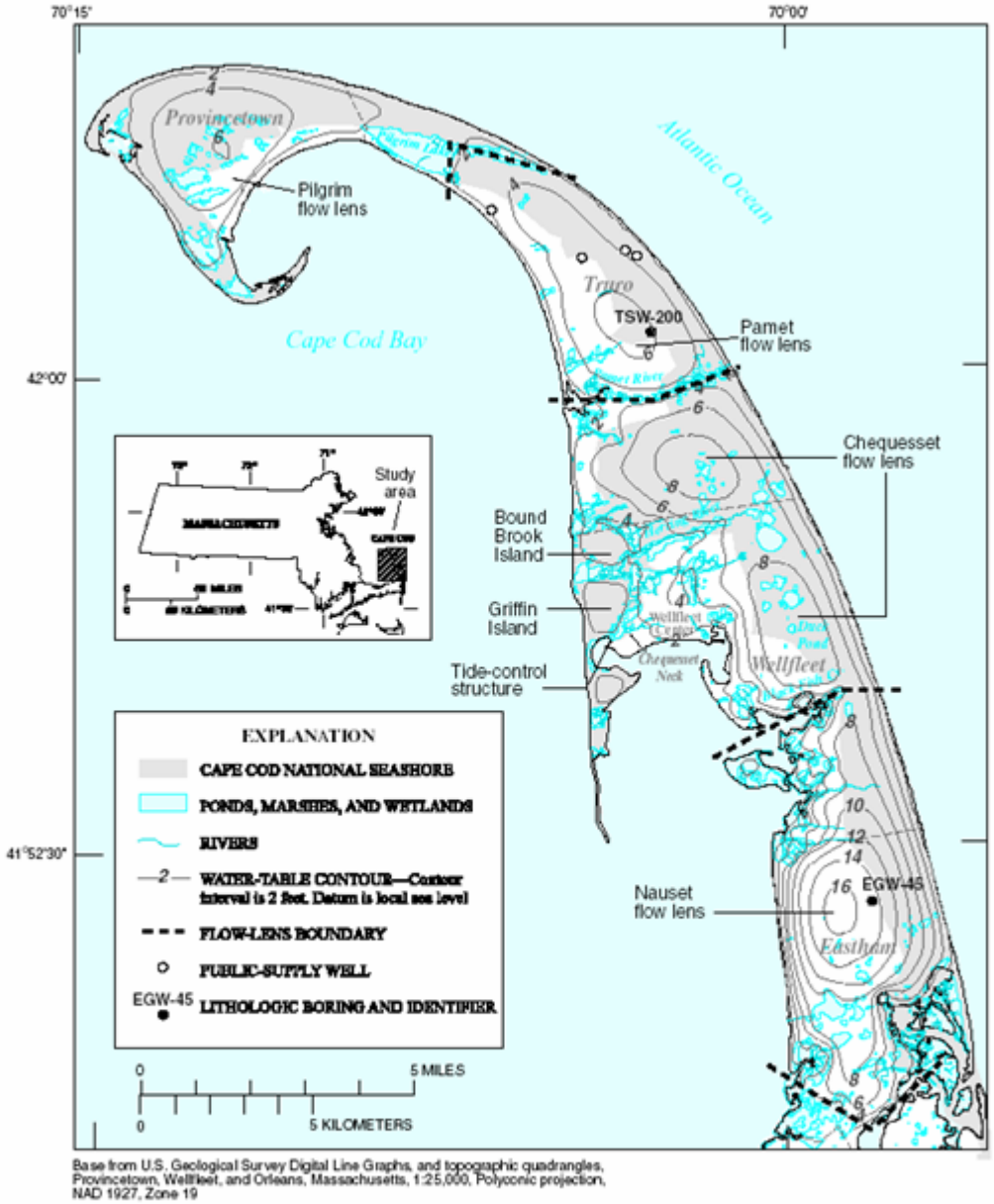
Predicting the response of vernal wetland vegetation to lowering of the water table from groundwater withdrawal: *Cape Cod National Seashore*

Charles T. Roman
National Park Service
North Atlantic Coast CESU

John W. Portnoy
National Park Service
Cape Cod National Seashore

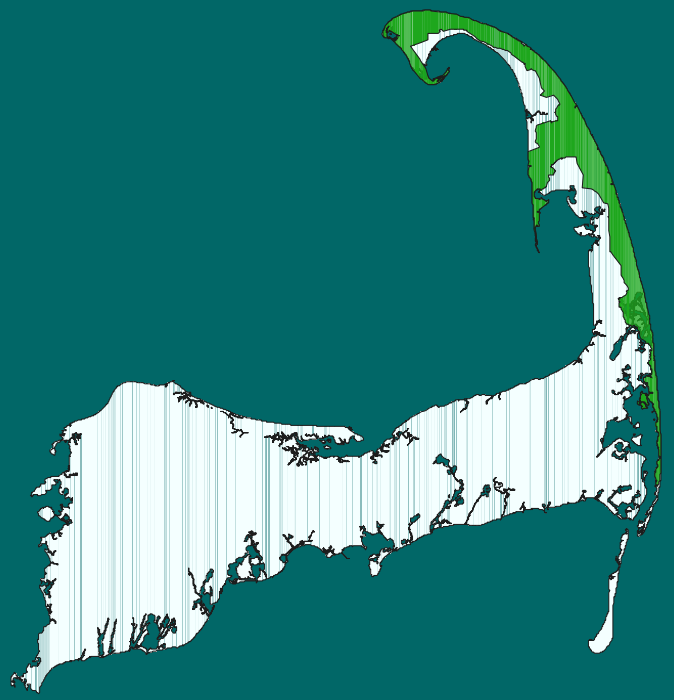
Robert V. Sobczak
Cape Cod Commission

Nels E. Barrett
NRCS



Base from U.S. Geological Survey Digital Line Graphs, and topographic quadrangles, Provincetown, Wellfleet, and Orleans, Massachusetts, 1:25,000, Polyconic projection, NAD 1927, Zone 19

Figure 1. Location of the four flow lenses of the Lower Cape Cod aquifer system and model-calculated water-table contours, Cape Cod, Massachusetts.



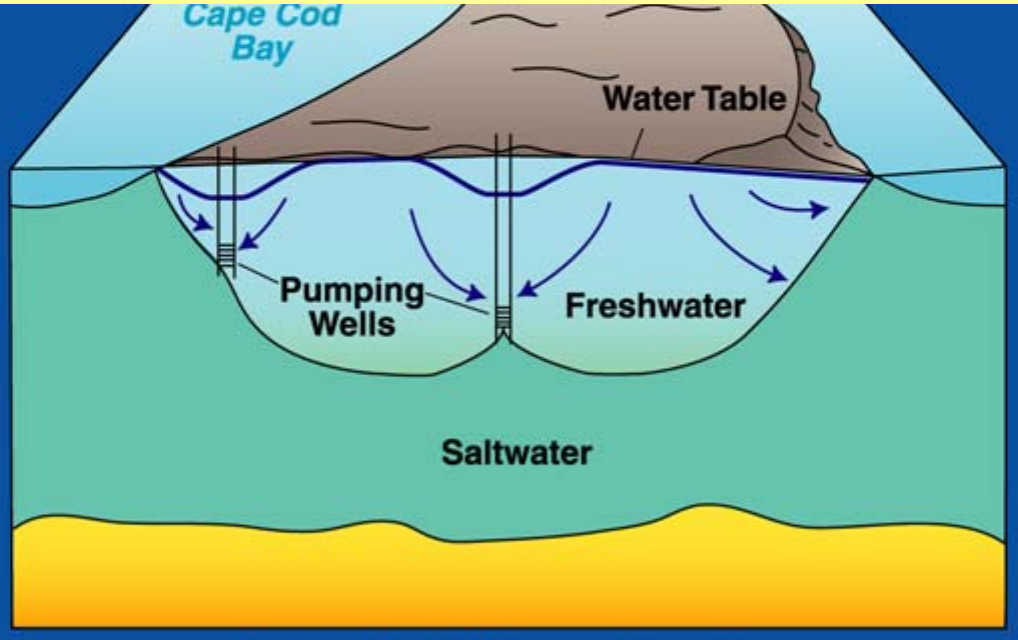
ISSUE:

Ongoing debate regarding the placement of municipal wells on outer Cape Cod

Study Objectives:

-- Evaluate relationships between hydrologic regime (water table level) and plant communities

-- Predict vegetation changes in response to a simulated municipal pump well



Cape Cod, Massachusetts

USGS
science for a changing world

Study Design
A Gradient Approach

Encompassed the range of vegetation and soil characteristics along a broad hydrologic gradient by;

1) **sampling 3 vernal wetland sites ranging from wet to dry**

2) **sampling a continuum from upland to wetland conditions**

3) **sampling during both wet (1997) and dry (1999) years**

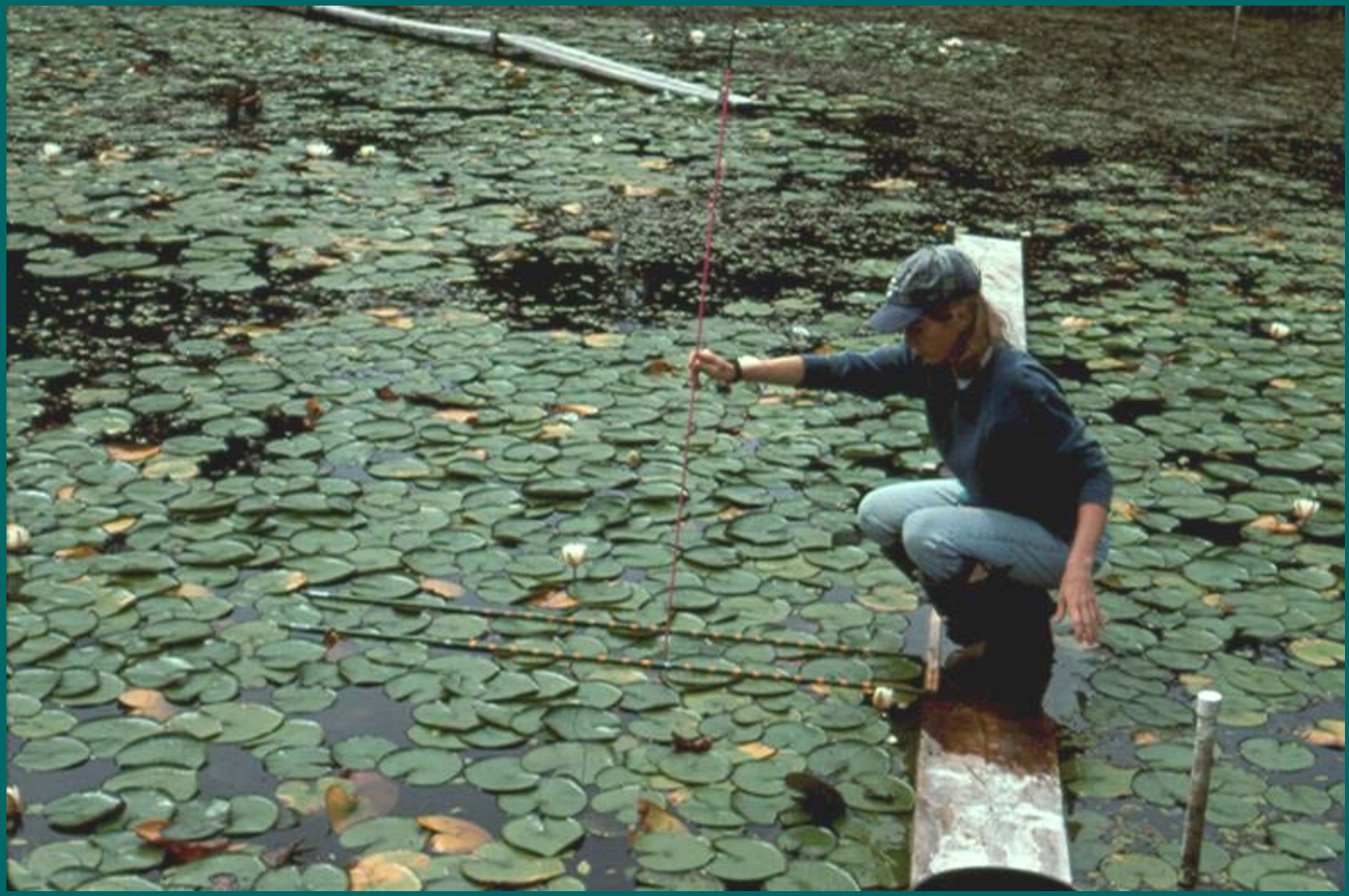
Shrub-dominated (E2)

Rush-Meadow (E8)

Wet Year, 1997

Drought Year, 1999

Aquatic-dominated (E9)



Sampling along the upland-to-wetland gradient

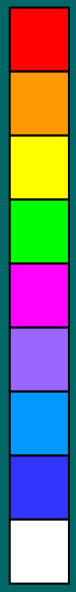
Hydrology and soils
-- water table level
-- porewater pH
-- soil nutrients

Vegetation species comp and abundance
-- 0.5m^2 plots
-- point intercept

TWINSPAN
-- Plant Community Classification --

The range of plant communities encountered at all 3 sites, during both wet and dry sample years

KEY TO VERNAL WETLAND COMMUNITIES



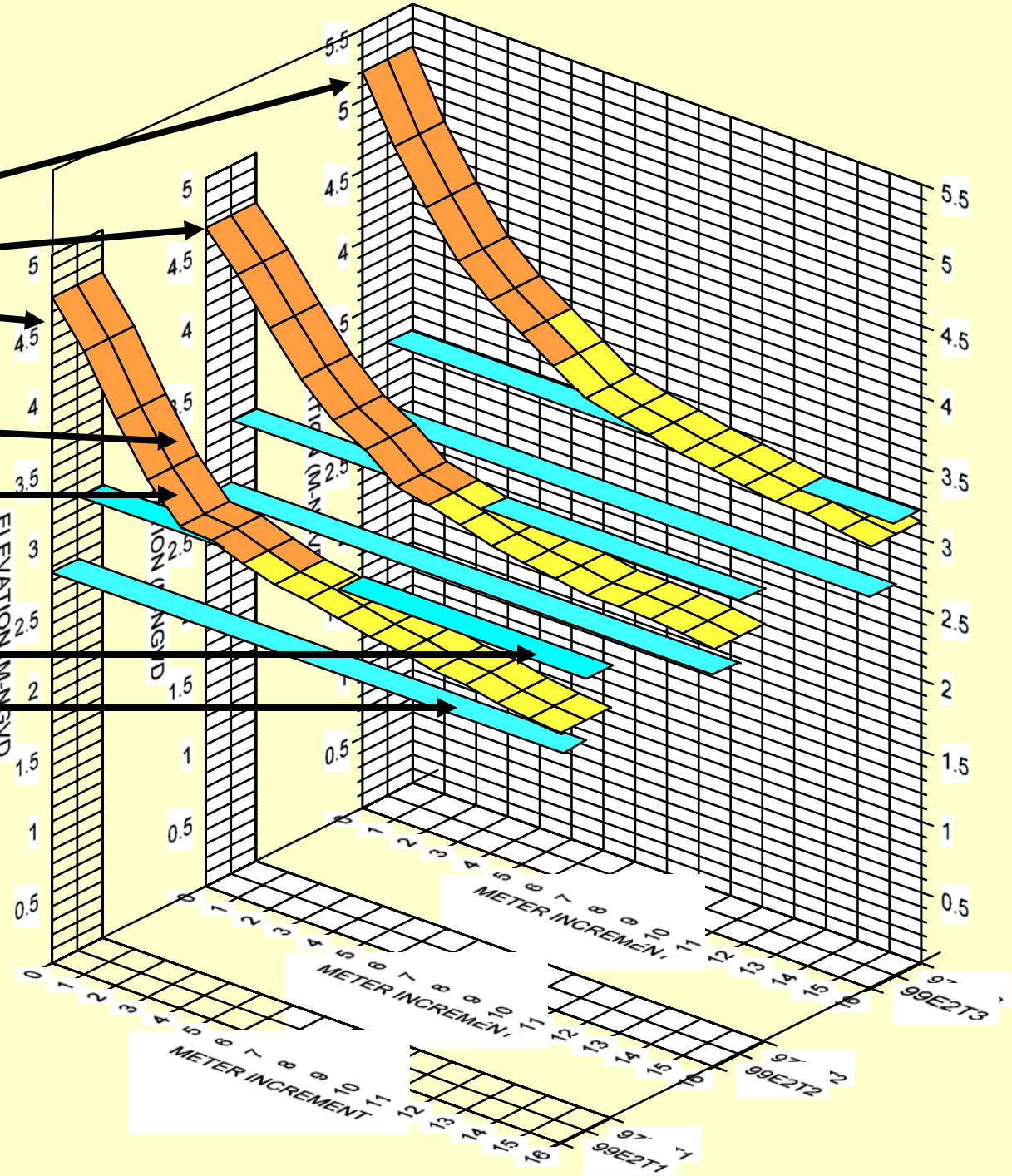
1a. DRY OPEN WOODLAND *Vaccinium / Quercus*
1b. DRY OPEN WOODLAND *Smilax / Clethra*
2a. SWAMP SHRUB THICKET *Decodon / Clethra*
2b. SWAMP SHRUB THICKET *Chamaedaphne*
3a. WET RUSH MEADOW *Juncus militaris*
3b. WET RUSH MEADOW *Juncus canadensis*
4. DRAWDOWN WET MEADOW *Hypericum*
5. OPEN WATER/AQUATIC BED *Potamogeton*
6. OPEN WATER, NO VEGETATION

Vernal Wetland E2
Shrub-dominated

-- 3 transects, 0.5m² plots

Sampled in wet (97) & dry (99) years

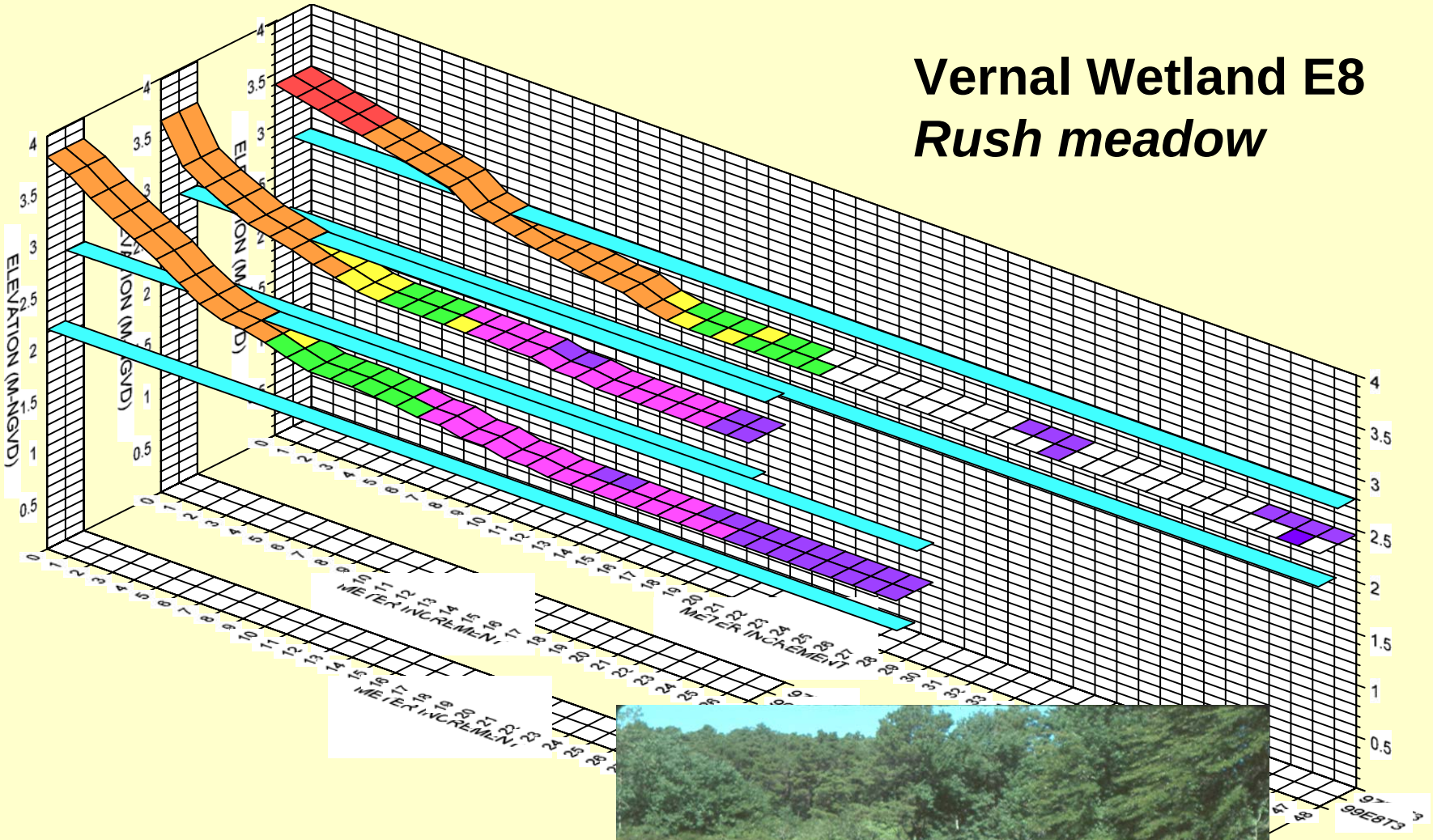
Water table, wet (97) & dry (99) yrs



KEY TO VERNAL POOL PLANT COMMUNITIES

1a. DRY OPEN WOODLAND *Vaccinium / Quercus*
1b. DRY OPEN WOODLAND *Smilax / Clethra*
2a. SWAMP SHRUB THICKET *Decodon / Clethra*
2b. SWAMP SHRUB THICKET *Chamaedaphne*
3a. WET RUSH MEADOW *Juncus militaris*
3b. WET RUSH MEADOW *Juncus canadensis*
4. DRAWDOWN WET MEADOW *Hypericum*
5. OPEN WATER/AQUATIC BED *Potamogeton*

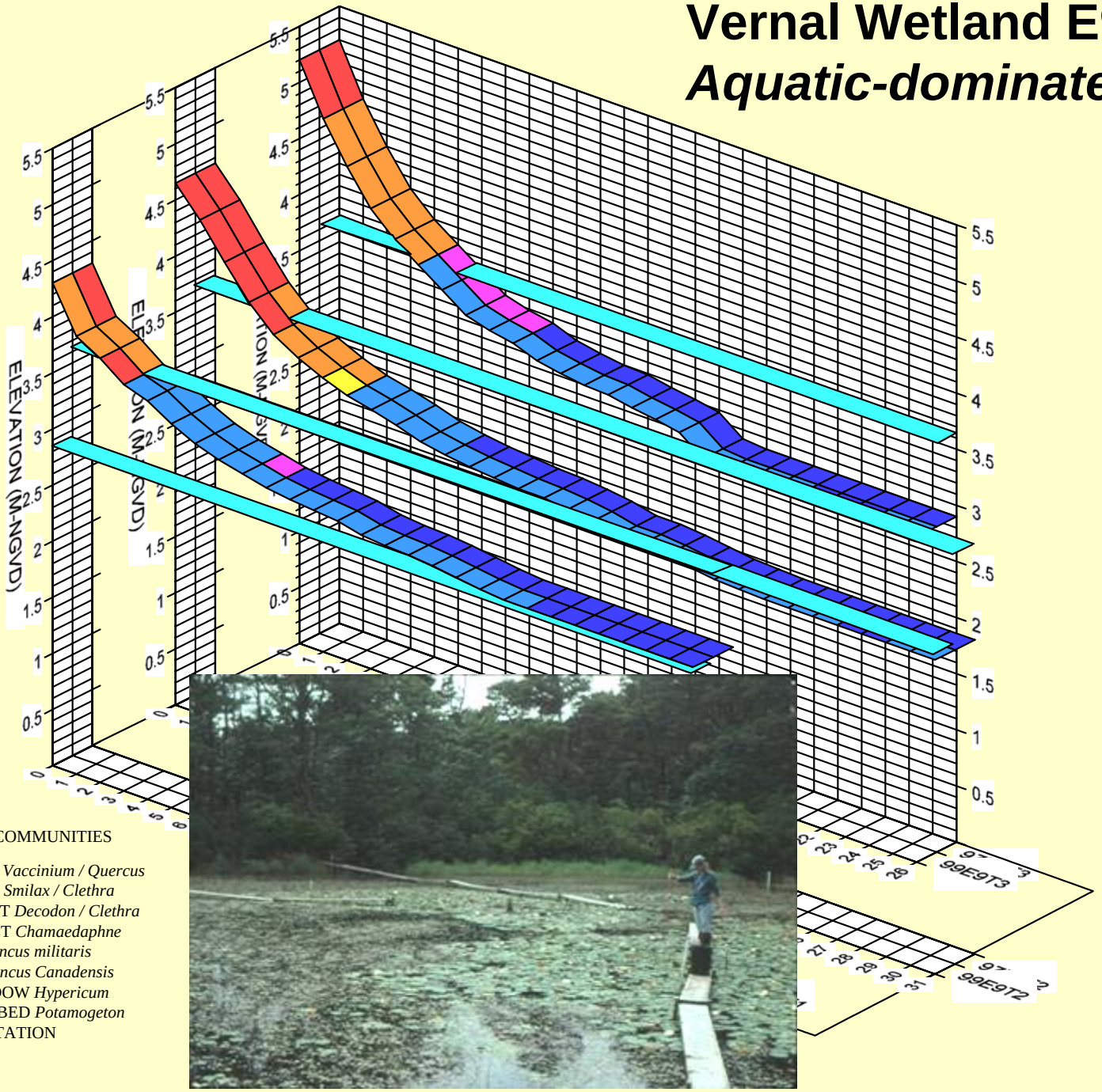
Vernal Wetland E8
Rush meadow



KEY TO VERNAL POOL PLANT COMMUNITIES

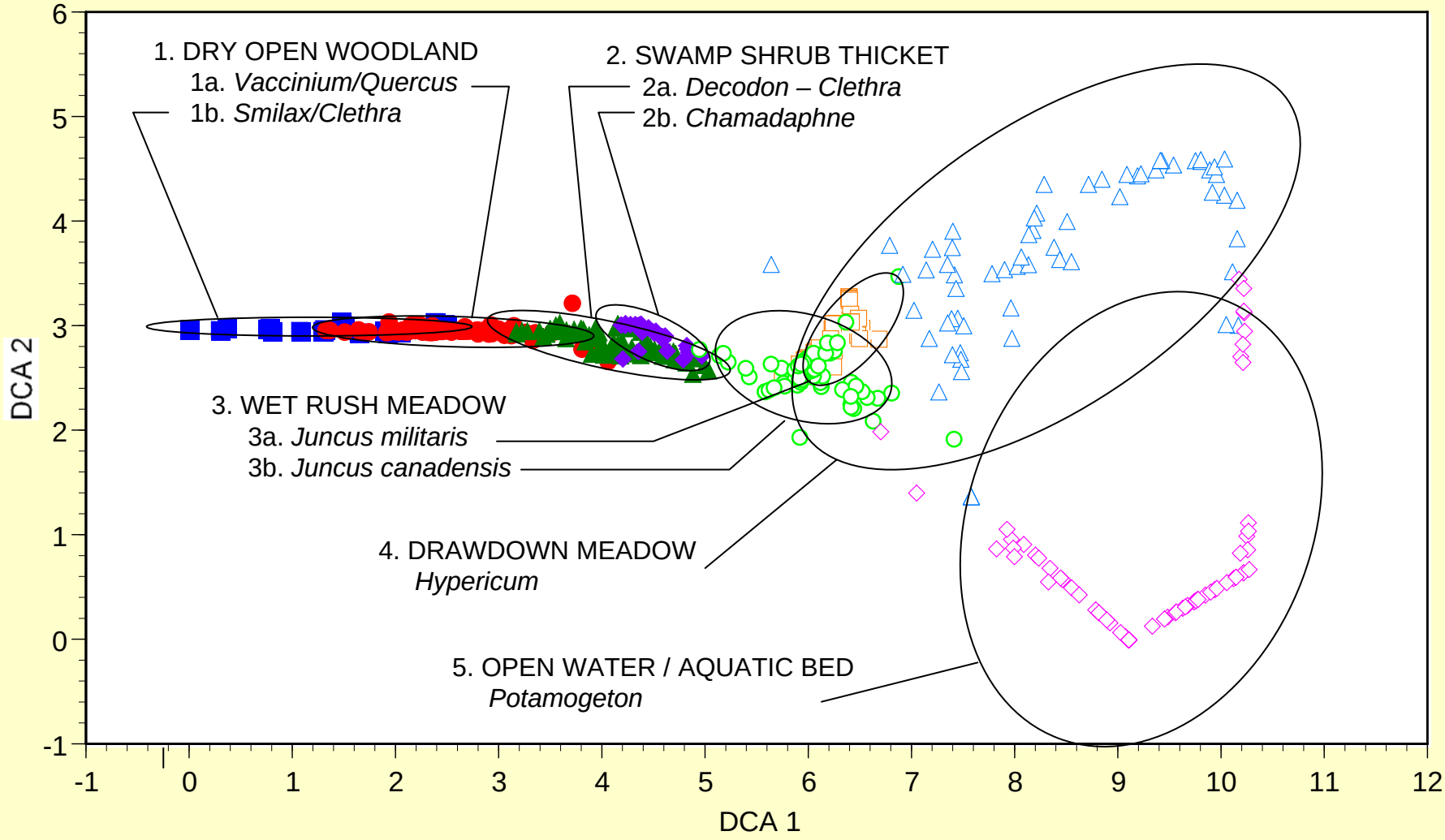
1a. DRY OPEN WOODLAND *Vaccinium / Quercus*
1b. DRY OPEN WOODLAND *Smilax / Clethra*
2a. SWAMP SHRUB THICKET *Decodon / Clethra*
2b. SWAMP SHRUB THICKET *Chamaedaphne*
3a. WET RUSH MEADOW *Juncus militaris*
3b. WET RUSH MEADOW *Juncus Canadensis*
4. DRAWDOWN WET MEADOW *Hypericum*
5. OPEN WATER/AQUATIC BED *Potamogeton*
6. OPEN WATER, NO VEGETATION

Vernal Wetland E9
Aquatic-dominated

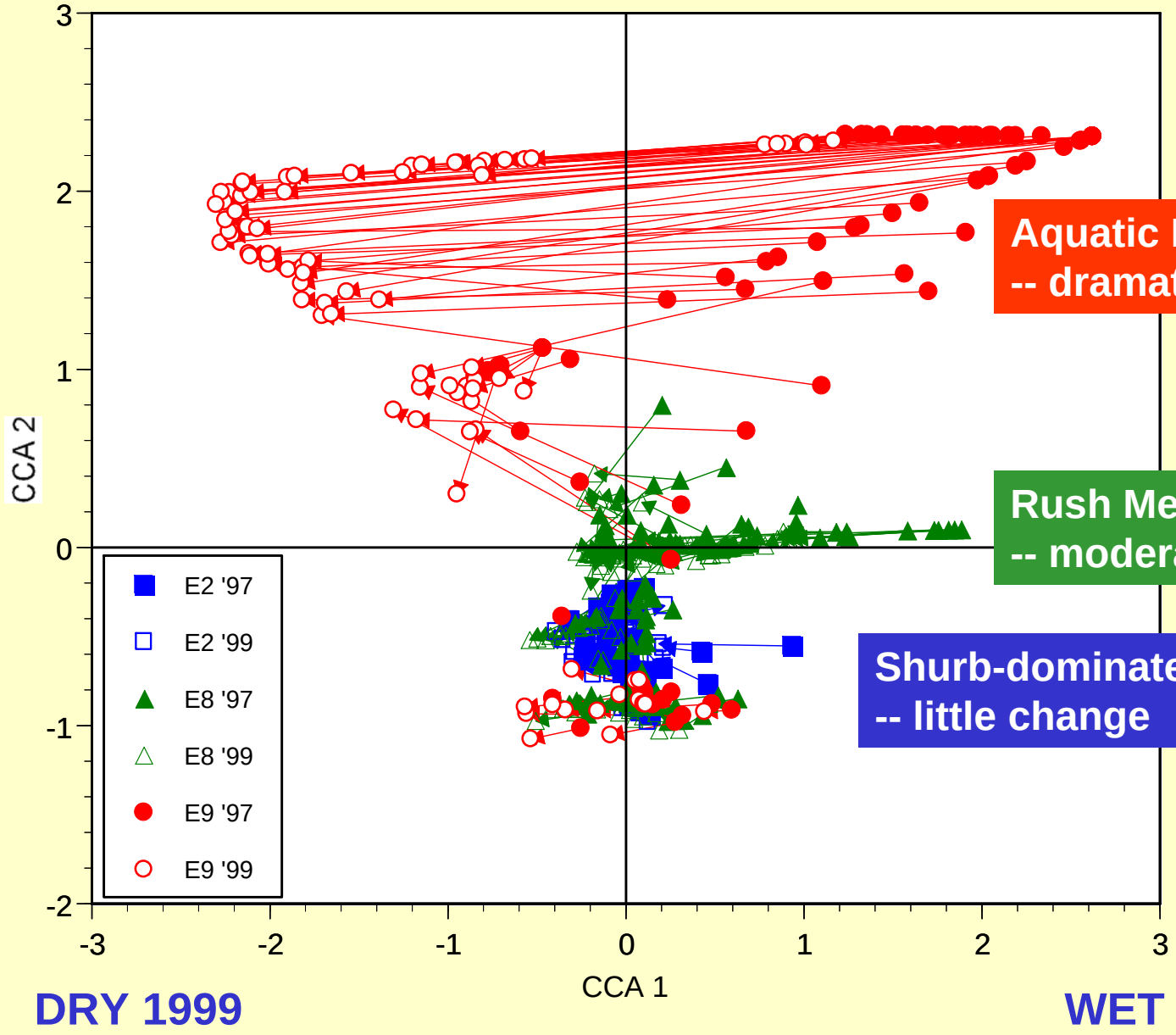


KEY TO VERNAL POOL PLANT COMMUNITIES

1a. DRY OPEN WOODLAND *Vaccinium / Quercus*
1b. DRY OPEN WOODLAND *Smilax / Clethra*
2a. SWAMP SHRUB THICKET *Decodon / Clethra*
2b. SWAMP SHRUB THICKET *Chamaedaphne*
3a. WET RUSH MEADOW *Juncus militaris*
3b. WET RUSH MEADOW *Juncus Canadensis*
4. DRAWDOWN WET MEADOW *Hypericum*
5. OPEN WATER/AQUATIC BED *Potamogeton*
6. OPEN WATER, NO VEGETATION


1. DRY OPEN WOODLAND
1a. Vaccinium/Quercus
1b. Smilax/Clethra
2. SWAMP SHRUB THICKET
2a. Decodon – Clethra
2b. Chamadaphne
3. WET RUSH MEADOW
3a. Juncus militaris
3b. Juncus canadensis
4. DRAWDOWN MEADOW
Hypericum
5. OPEN WATER / AQUATIC BED
Potamogeton
DCA 2
DCA 1
6
5
4
3
2
1
0
-1
-1
0
1
2
3
4
5
6
7
8
9
10
11
12

Vegetation changes from wet-to-dry year



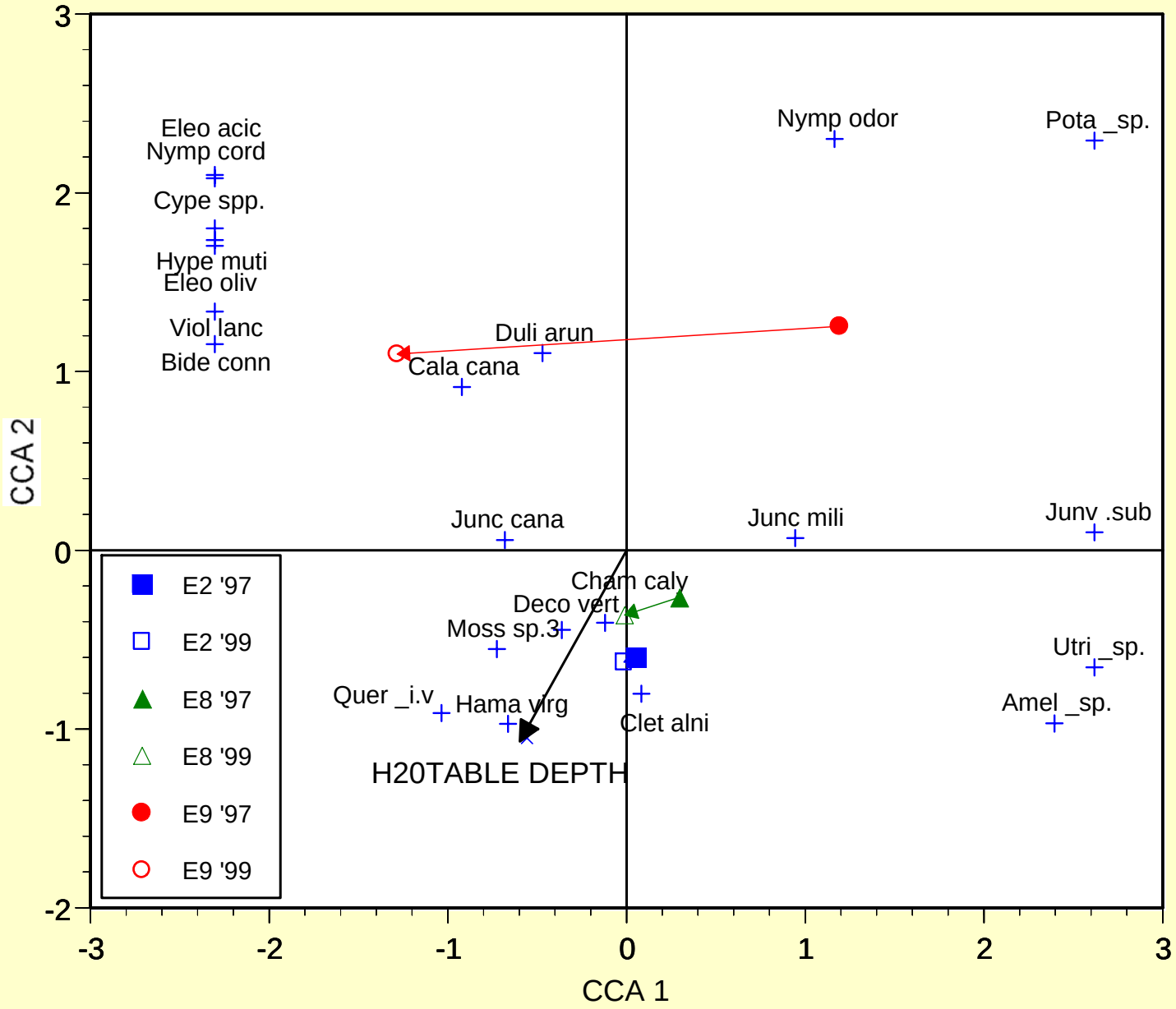
Aquatic Bed
-- dramatic change

Rush Meadow
-- moderate change

Shurb-dominated
-- little change

DRY 1999

WET 1997


Eleo acic
Nymp cord
Cype spp.
Hype muti
Eleo oliv
Viol lanc
Bide conn
Nymp odor
Pota _sp.
Duli arun
Cala cana
Junc cana
Junc mili
Junv .sub
Cham caly
Deco vert
Moss sp.3
Utri _sp.
Quer _i.v
Hama virg
Clet alni
Amel _sp.
H20TABLE DEPTH
E2 '97
E2 '99
E8 '97
E8 '99
E9 '97
E9 '99
CCA 1
CCA 2
3
2
1
0
-1
-2
-3
-2
-1
0
1
2
3

Predicting water table drawdown with pumping

(Sobczak, Cambareri and Portnoy, 2003)

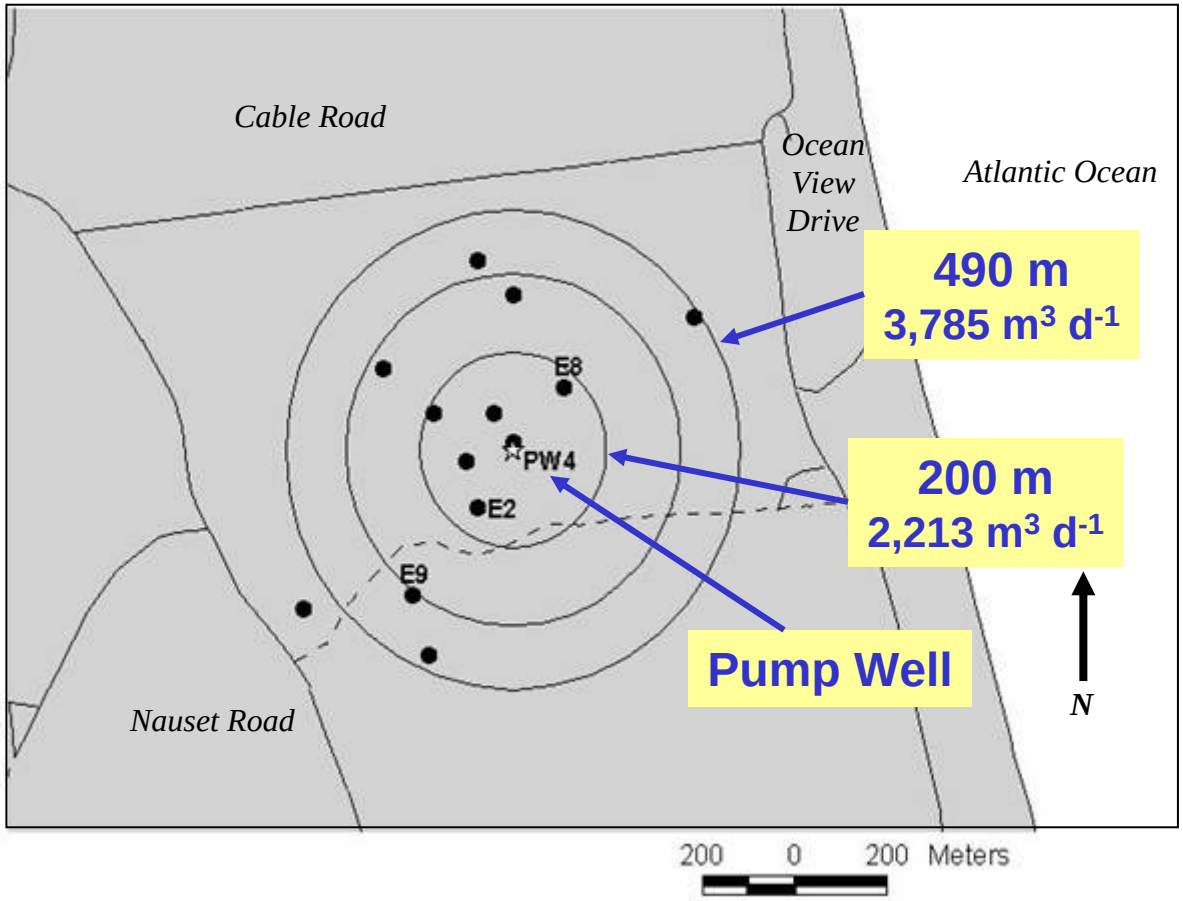
- **Surface and groundwater level monitoring throughout study area**
- **Analytical model developed**
- **Calibrated from a historic (1970) pump test at the study area**

Modeled Water-table Drawdown with Pumping

Distance from Pump Well (m)	Water Table Decline (cm)	
	Pump Rate 2,213m^3 d^{-1}	Pump Rate 3,785m^3 d^{-1}
15	75	107
110	11	50
140	9	42
160	4	38
180	1	33
300	0	16
360	0	10
410	0	7
450	0	3
530	0	0

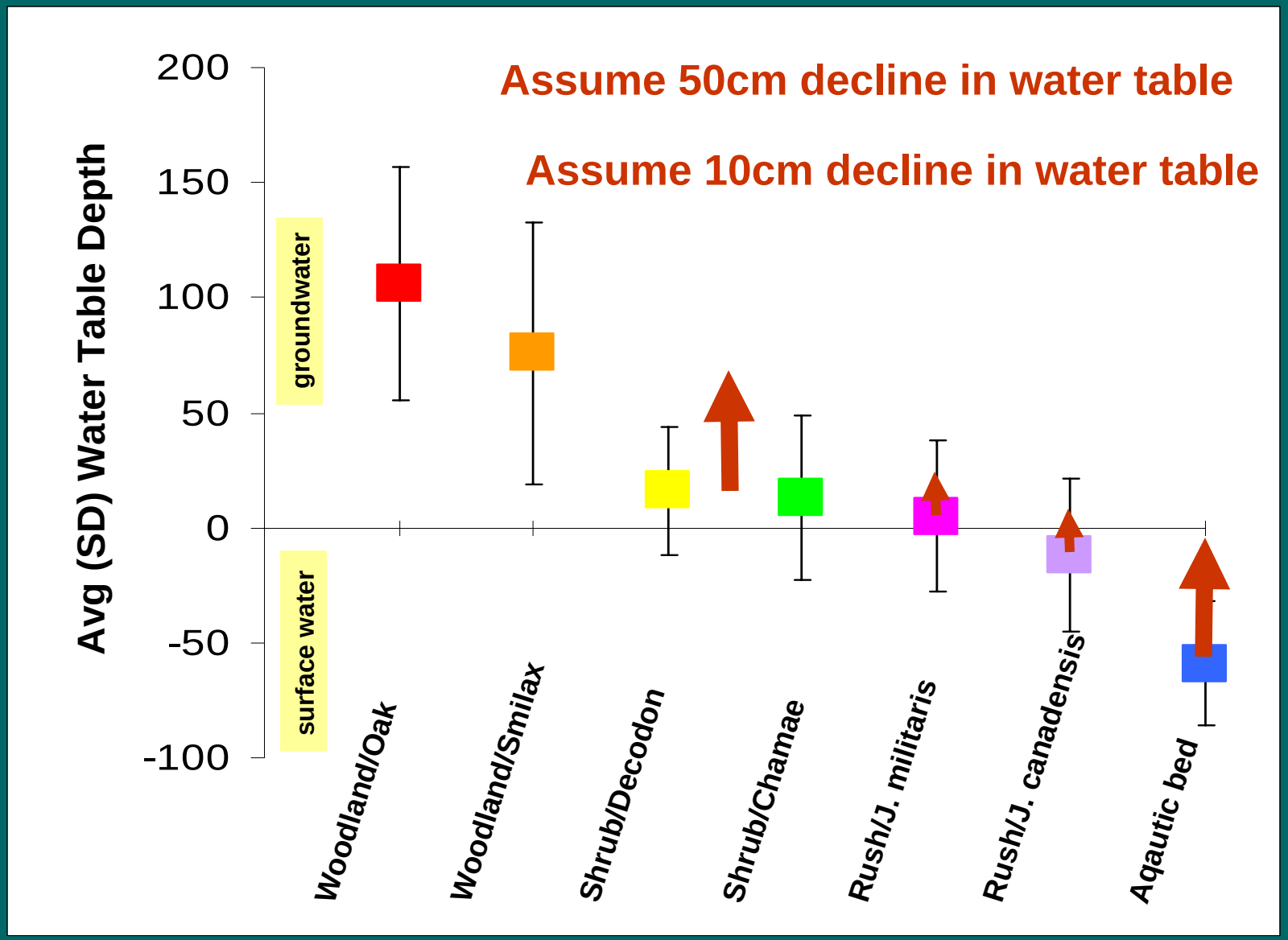
Source: Sobczak et al. 2003

Zone of Influence from Pumping Scenarios



Source: Sobczak et al. 2003

Average Water Table Depth for Plant Communities



CONCLUSIONS

- **Permanent water level declines of as little as 10cm could result in shifts of the wetter wetland classes to drier wetland classes (e.g., rush meadow to shrub-thicket)**

- **Permanent drawdown of 50cm, or more, could result in major shifts in community classes**
  -- aquatic bed to rush meadow
  -- rush meadow to shrub-dominated
  -- shrub wetland to upland

- **In response to short-term hydrologic drawdown, shrub-dominated wetland classes are quite stable, but under permanent drawdown conversion to upland would be expected**

- **The gradient approach to characterizing wetland vegetation in relation to hydrology, coupled with predictive hydrologic modeling, appears to be a reasonable method.**